CHAPTER 7

ENGINE INTAKE AND EXHAUST SYSTEMS

7-1. Minimum maintenance activities for engine intake and exhaust systems

The tables that follow indicate items that must be performed to maintain systems and equipment at a minimum level of operational readiness. The listed minimum action items should be supplemented by manufacturer-recommended maintenance for specific pieces of equipment. These should be used to develop a comprehensive maintenance plan for the facility. Maintenance actions included in this chapter are for various modes of operation, subsystems, or components. Table 7-1 provides maintenance information for basic air intake and exhaust systems. Table 7-2 provides maintenance information for complex air intake and exhaust systems. Table 7-3 provides maintenance information for chemical, biological, and radiation (CBR) filter banks. Table 7-4 provides maintenance information for air intake and exhaust controls and instrumentation.

7-2. General maintenance procedures for engine intake and exhaust systems

This section presents general instructions for maintaining the types of components associated with engine intake and exhaust systems.

a. Intake air filter assembly. In this manual, the intake air filter assembly is considered to be a stand-alone filter unit, either mounted on or very close to the device being served. If the device being served is a diesel engine, gasoline engine, or any piece of rotating equipment, maintenance involving any disassembly of the intake air filter unit should not be performed while the engine is operating.

(1) Before removing filter elements, remove loose accumulations of dirt from face of filter and face of filter housing.

(2) After removing filter elements, wipe clean filter seating surfaces. For units with separate gaskets, replace gaskets at each filter change. Lubricate gasket or seal surfaces prior to installation as recommended by the equipment manufacturer.

(3) Carefully align new filter element in filter housing. Do not force filter elements, filter element hold-downs, or filter housing components into place.

(4) Lock filter elements and filter housing components into place as recommended by the manufacturer. Be sure all nuts, bolts, screws, and other fasteners are secure and cannot be sucked into the intake system.

b. Static element filter banks. Typical static element filter banks are made of a rectangular array of filter elements. Each individual filter element is usually mounted in a rectangular frame and can be comfortably handled by one person. The filter elements then either slide into the filter bank frame from the side or are snapped into the front or back of a holding frame which is part of the overall filter bank frame.

(1) Where a filter assembly is relatively small and is directly connected to a piece of rotating equipment, maintenance that requires the filter housing to be open so that intake air bypasses the filters

for a long period of time, or requires any disassembly of the filter housing should not be performed with the device being served in operation if possible. Large, walk-in filter assemblies may be maintained with the system in operation. When working in filter plenums, do not block doors between filter banks open.

(2) Accumulations of dirt between filter banks may indicate a hole in the filter housing, an improperly seated filter element, a damaged gasket or seal, or a damaged filter. When unusual accumulations of dirt are observed, determine the cause. Make any corrections possible at time of inspection; report problems that cannot be fixed on the spot for follow-up work. Vacuum plenums to remove accumulations of dirt. When replacing a filter element or changing out a filter bank:

(a) Before removing filter elements, remove loose accumulations of dirt from face of filter and face of filter housing.

(b) After removing filter elements, wipe clean filter seating surfaces. For units with separate gaskets, replace gaskets at each filter change. Lubricate gasket or seal surfaces prior to installation as recommended by the equipment manufacturer.

(c) Carefully align new filter element in filter housing. Do not force filter elements, filter element hold-downs, or filter housing components into place.

(d) Lock filter elements and filter housing components into place as recommended by the manufacturer. Be sure all nuts, bolts, screws, and other fasteners are secure and cannot be sucked into the intake system.

(e) Keep to a minimum the total number of filter elements removed at any one time when changing filter elements in an operating system.

c. Inspect air intake and exhaust system. Start at the air intake portal and follow the air intake and exhaust system to the exhaust portal. Inspect for:

(1) Obstructions to the air intake or exhaust portals

(2) Obstructions to the face area of filters

(3) Dirty filters (high pressure drop)

(4) Damage to or deterioration of filter housings, filters, fan housings, ducts, expansion joints, etc., that would allow unfiltered air into the system.

(5) Damage to or deterioration of exhaust ducts, expansion joints, silencers, etc., that would allow exhaust gases, or contaminants from other sources, to leak into occupied spaces.

(6) Obstructions in bypass dampers, isolation valves, and device operators that would prevent free movement of the device.

(7) Deformed expansion joints

(8) Misaligned or sagging duct sections

(9) Deformed or broken duct support devices. Verify that support devices designed to accommodate movement of the duct are free to operate.

(10) Unusual noise, vibration, or overheating

(11) Loose mechanical or electrical connections

(12) Missing components

(13) Low lube oil levels in equipment with lube oil sumps

(14) Misalignment of drives, worn belts and pulleys, and loose drive belts on belt-driven equipment

(15) Damaged or missing equipment guards

(16) Damaged or missing insulation

(17) Damaged or missing equipment tags

d. Exercise bypass dampers and isolation valves. Exercise all bypass dampers and exhaust system isolation valves in the air intake and exhaust system.

(1) Verify free operation of dampers and valves.

(2) Inspect any packing glands and tighten as necessary.

(3) Check for leaking seals.

(4) Wipe damper and valve operators clean, apply a light coat of protective oil to exposed operating shafts, and lubricate bearings and pinned connections.

(5) Adjust operator linkages for proper valve positioning, and adjust limit switches for proper position indication.

e. Test alarms. Verify operation of system alarms and alarm system by actuating appropriate system test push buttons. Verify that the audible alarm sounds and that all warning and annunciator lights operate.

f. Manometers. Inspect all manometers and service as required:

(1) For incline manometers, check manometer level and adjust as required.

(2) To zero manometers equipped with maintenance valve, turn valves to vent position, or if direct-connected, disconnect high- and low-pressure tubes. Loosen retaining screw on adjustable scale and slide scale until the zero mark is directly behind the fluid meniscus. Tighten retaining screw. Close vent valves, or reconnect high- and low- pressure reference tubes.

(3) If manometer fluid level is not within the scale adjustment range, add gauge fluid. Before adding fluid, set adjustable scale at approximate midpoint of range of adjustment. Verify that gauge fluid of the correct specific gravity has been obtained.

g. Belt drives. When belt replacement is required, replace multiple belts as a set. Loosen drive motor mounting, and slide motor toward driven shaft so that belts may be installed by laying belts onto pulleys. Do not lever belts onto pulleys, and ensure that belt covers are replaced after maintenance. Check belt tension several times during first 48 hours that new belts are in operation, and adjust belt tension as required.

(1) When belt tension adjustment is required, consult the belt manufacturer's literature for the proper tension force (and belt deflection to achieve that force). Deflect each belt at the midpoint between the pulleys to the deflection recommended, and read the belt tension. Adjust the tension as required. Many belts have an initial run-in period tension (usually about 48 hours) and then a broken-in tension. Generally, if the tension reading differs more than 2 pounds from the recommended reading, the belt tension should be adjusted. If a belt tension measuring device is not available, belt tension may be checked by observing the deflection when pressing down on each belt at about the midpoint between the pulleys. If the tension is correct, the belt deflection will be about one belt thickness for each 4 feet of center-to-center distance between the pulleys. Caution should be used in using this method because there are many different belt designs available for the same service, and each belt design may have different tension and deflection characteristics. To tension the belts, loosen the motor hold-down bolts. Move the motor away from the driven shaft to increase the tension and toward the driven shaft to decrease the tension. (If the motor is on a slide base, it will not be necessary to loosen the motor hold-down bolts. Adjustment is accomplished using the slide base positioning screw.) Tighten the motor hold-down bolts. Run the equipment for a short period of time, and then check the belt tension.

(2) When drive alignment is required, lay a straightedge across both the driver and driven pulleys. The straightedge should contact each pulley in two places. If the pulleys are not aligned, verify that the drive shaft and driven shaft are parallel. If the shafts are not parallel, adjust the motor so the shafts are parallel. When the shafts are parallel, adjust the positions of the pulleys on the shafts to achieve alignment. Verify that the driven pulley is in the correct position on the driven shaft and that the pulley is firmly locked in place. Loosen the pulley on the motor shaft, and move the pulley into alignment with the driven pulley. Tighten the pulley on the shaft, install and tension the drive belts, and run the equipment for a short period of time. Check drive alignment and adjust as required.

h. Fan clearance adjustment. After long service, the running clearances in some types of fans may increase to the point where the fan is losing capacity or pressure. Resetting the end clearance will normally improve fan performance. Refer to the manufacturer's technical service manual.

i. Examine internal parts of rotating equipment. Periodically, remove casing access covers and inspect components for wear. Replacing a relatively inexpensive part after only moderate wear can eliminate the need to replace more expensive parts at a later date.

j. Clean all equipment. Clean equipment is easier to inspect, lubricate, and adjust. Clean equipment also runs cooler and looks better.

k. Inspect rotating equipment. Inspect rotating components daily. Check for unusual noises or vibrations, and overheating or similar inconsistencies. Investigate any conditions that do not "feel" right.

Table 7-1. Basic air intake and exhaust systems

Basic Air Intake & Exhaust Systems	
Action	***Frequency***
NOTE! THIS TABLE APPLIES TO SYSTEMS WITH AN INTAKE AIR FILTER ASSEMBLY AND AN EXHAUST SILENCER EITHER MOUNTED ON THE ENGINE OR VERY CLOSE COUPLED (NO LONG SECTIONS OF INTAKE OR EXHAUST DUCT WITH A COMPLEX SUPPORT SYSTEM).	
Intake Air Filter Assembly	
Inspect and service as required. Inspection and servicing shall include the following:	
Verify that the air intakes are free of obstructions; remove obstructions as required.	day
Check the pressure drop across the filter elements (or the pressure in the engine air intake manifold) and clean or replace filter elements as required.	day
Exhaust Discharge Point	
Verify that the exhaust discharge point is free of obstructions; remove obstructions as required.	day
Overall Intake and Exhaust System	
Inspect all air intake and exhaust system piping and/or ducts and system components; report all discrepancies to supervision. Inspection shall include the following:	
Look for leaks and corrosion.	week
Look for visible cracks and/or deformation of expansion joints.	week
Look for broken and/or deformed system supports.	week
Look for damaged insulation.	week

Table 7-2. Complex air intake and exhaust systems

Complex Air Intake & Exhaust Systems	
Action	***Frequency***
NOTE! THIS TABLE APPLIES TO PARTICULATE REMOVAL SYSTEMS USING A SERIES OF FILTER BANKS WITH ARRAYS OF FILTER ELEMENTS. THE FILTER SYSTEMS MAY BE DUCTED DIRECTLY TO THE DEVICE BEING SERVED, MAY BE A STAND-ALONE UNIT FILTERING MAKEUP AIR INTO AN OCCUPIED SPACE, OR A COMBINATION OF MAKEUP INTO A SPACE AND DUCTED FROM THE SPACE TO THE ENGINE (OR DEVICE) USING COMBUSTION AIR. CBR FILTERS, WHICH ARE NOT PARTICULATE FILTERS, ARE COVERED ON A SEPARATE TABLE.	
Facility Air Intake and Exhaust Points	
Inspect intake and exhaust points for obstructions; remove obstructions as required.	week
Filter Assemblies	
Inspect filter assemblies and report all discrepancies to supervisor. Inspection shall include:	
Visually verify that all filters are properly installed; adjust as required.	week
Inspect each bank for large debris obstructing the flow of air through the bank; remove obstruction as required.	week
Inspect interior of filter housing for accumulations or dirt; clean as required.	week
Inspect individual filter elements for damage; repair or replace as required.	week
Check pressure drop across each bank; clean or replace bank as required.	week
Roll Filters	
In addition to the general checks listed above, roll filter units require additional checks as follows:	
Lubricate trunnion bearings.	week
Verify that electric power is to the unit.	week
Verify that the unit is operating; repair or adjust as required.	week
Check pressure drop across filter and check roll filter control settings; adjust as required.	week
Check exposed media for damage; repair, advance media past damage, or replace as required.	week
Check quantity of media remaining on feed roll. Verify that replacement roll is available.	week

Table 7-2. Complex air intake and exhaust systems (continued)

Complex Air Intake & Exhaust Systems	
Action	***Frequency***
Install new roll of media. At installation of new filter media, service roll filter unit as follows and as required:	
Clean roll filter unit to remove accumulations of dirt.	as req'd
Wipe clean and lubricate trunnion bearings.	as req'd
Wipe clean drive motor and lubricate as required.	as req'd
Filter Assembly Bypass Dampers and Air Flow Control Dampers	
Inspect damper assemblies, and report all discrepancies to supervisor. Inspection shall include:	
Verify damper position relative to facility mode of operation.	week
Exercise dampers to verify free operation; repair or adjust as required.	mo
Inspect seals and seal contacting surfaces for full contact; adjust seals and/or repair seals and seal contacting surfaces as required.	mo
Wipe clean damper operator and connecting linkages; apply a light coat of oil.	mo
Clean and inspect bearings; lubricate and adjust bearings as required.	mo
Intake Air Fan	
Inspect fan and report all discrepancies to supervisor. Inspection shall include:	
Check for unusual vibration or noise.	week
Verify drive guards are in place.	week
Visually check drive alignment (and, if belt drive, check for damaged belts).	week
Service fan and fan components. Service shall include:	
Lubricate bearings.	3 mo
Wipe motor clean, clear motor ventilation passages, and lubricate motor as required.	3 mos
Check drive alignment; adjust as required and tighten any loose bolts.	3 mos
If belt drive, inspect pulleys and belts; repair or replace as required; adjust belt tension.	3 mos
If direct-connected or connected through a gear box, inspect shaft couplings, tighten loose bolts, and repair or replace as required. Check lube oil in gearbox; add oil as required.	3 mos
Open fan housing inspection cover, remove accumulations of dirt, and inspect internal components for wear; report all discrepancies to supervisor.	3 mos

Table 7-2. Complex air intake and exhaust systems (continued)

Complex Air Intake & Exhaust Systems	
Action	***Frequency***
Overall System (Air Intake Through Exhaust Port)	
Inspect the air intake and exhaust system; report all discrepancies to supervisor. Work through the system inspecting all devices, assemblies, components, etc., that are part of the intake and exhaust system. Inspection shall include intake and exhaust components that are part of the device being served. Inspection shall include:	
Verify that all components are present and are properly installed; clean, lubricate, tighten, and adjust as required.	mo
Inspect access doors, hatches, and panels, and seal units for proper fit and leaks, tighten, and replace and adjust as required.	mo
Inspect equipment housings and ducts for leaks and/or corrosion; report condition.	mo
Inspect air intake and exhaust manifolds for leaks at joints or visible cracks; report condition.	mo
Inspect expansion joints for visible cracks and/or deformation of expansion joints; report condition.	mo
Inspect ducts for proper support (no sagging or misalignment); report condition.	mo
Inspect duct hanger system for broken and/or deformed hangers; report condition.	mo

Table 7-3. CBR filter bank

CBR Filter Bank	
Action	***Frequency***
NOTE! THE ACTIVATED CARBON SECTIONS OF THE FILTER MUST BE TESTED EVERY TWO YEARS FOR ABSORPTION USING THE FREON TEST. THE TEST IS TO BE PERFORMED BY THE U.S. ARMY EDGEWOOD ARSENAL, QUALITY ASSURANCE OFFICE. ALL GAS FILTERS MUST BE REPLACED EVERY FIVE YEARS WHETHER IN SERVICE OR NOT. ALL PORTIONS OF THE CBR FILTERS MAY BE OBTAINED FROM THE ARMY PROCUREMENT SUPPLY AGENCY (APSA) AT JOLIET, ILLINOIS. THE NECESSITY TO REPLACE THE FILTERS MUST BE ANTICIPATED IN ADVANCE TO ALLOW TIME TO PROCURE THE FILTERS.	
CBR Particulate Filter Element	
Check pressure drop across filter bank; replace particulate filter element as required.	mo
Activated Carbon Filters	
Test absorption of filters using the freon test. Replace filters as indicated by test.	2 yrs
Replace filters.	5 yrs
CBR Filter Assembly	
Inspect filter assembly and report all discrepancies to supervisor. Inspection shall include:	
Visually verify that all filters are properly installed; adjust as required.	mo
Inspect for large debris obstructing the flow of air through the bank; remove obstruction as required.	mo
Inspect interior of filter housing for accumulations or dirt; clean as required.	mo
Inspect individual filter elements for damage; repair or replace as required.	mo
Check pressure drop across each bank; clean or replace bank as required.	mo

Table 7-4. Air intake and exhaust instrumentation and electrical

Air Intake & Exhaust Instrumentation & Electrical	
Action	***Frequency***
Manometers	
Zero manometer; add fluid as required.	week
Thermometers	
Check for accuracy. Remove thermometers from their wells and check against calibrated thermometer in controlled temperature bath.	yr
Pressure Gauges	
Isolate pressure gauge by closing the proper valves. Remove and check in a fixture against a calibrated gauge. Adjust as required following equipment manufacturer's instructions.	yr
Motors	
Check and clean cooling airflow passages on electric motors as necessary so that nothing obstructs airflow.	6 mos
All Electrical Devices	
Check, clean, and tighten terminals at motors, starters, disconnect switches, etc.	6 mos
Wiring	
Check insulation on conductors in starters, switches, and junction boxes at motors for cracks, cuts, or abrasions. Replace wiring as required and correct cause of damage.	6 mos